

SOME ACCOUNT OF THE ANATOMY OF *CASSIDARIA*¹ *RUGOSA*
(LINN.).

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PLATE XV.

FOR the opportunity of examining the anatomy of this animal I am indebted to the kindness of Mr. Sykes, from whom I received it on the 14th June, 1904, it being trawled from a depth of 200 fathoms off the south-west coast of Ireland.

The animal, a full-grown male, was preserved in a solution of formaldehyde and much retracted in its shell. I was fortunate enough, however, in extracting it entire. The foot was rolled together, and the proboscis and tentacles partially retracted. I cannot find that the general anatomy of this species in its entirety has ever been described, though it must be pretty well known.

Kiener in his monograph of this genus gives some description of the animal and the anatomy of the pallial complex. I really cannot agree with his colouring of the animal, he making the colour of the foot and visible portion of the animal olive green, whereas, according to its captor, the colour of this specimen, when living, "was pale grey, much like the foot of a whelk," and, as preserved, the foot, head, and tentacles were of a pale yellowish pink colour, much like what is conventionally known as 'flesh colour,' the only pigmented portions being the proboscis and eyes.

Dr. N. Tiberi, in his paper "*Sur les espèces du genre Cassidaria qui vivent dans la Méditerranée*" (*Journal de Conchyliologie*, ser. III, vol. III, 1863), mentions this species, as figured by Kiener, and finds fault with his colouring.

Fischer gives some account and a figure of the liver of this species in his paper on the morphology of the liver of Gastropods. F. Bernard, in his beautifully illustrated paper, describing his researches on the pallial organs, minutely describes the osphradium and ctenidium.

Perrier gives a full account of the anatomy and histology of the renal organs in his paper on these organs in Prosobranchs; this, again, is beautifully illustrated. Finally, there are some notes on the anatomy of this species to be found in part II of Dr. Arnold Lang's "*Textbook of Invertebrate Comparative Anatomy*."

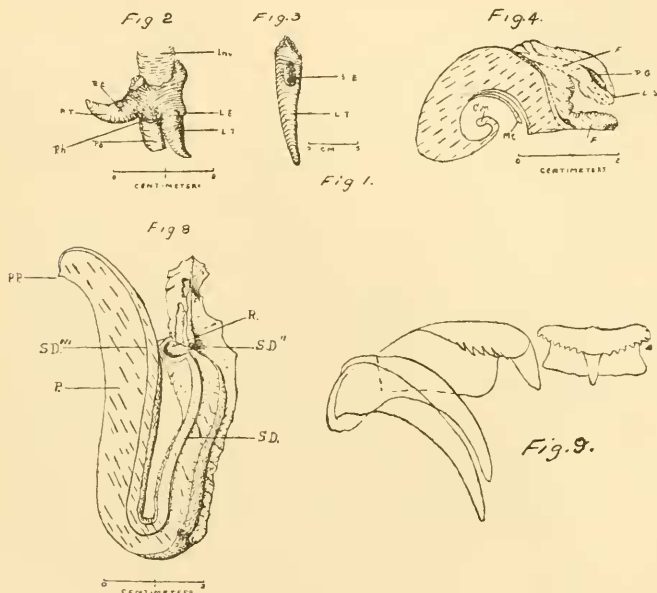
The *foot* (section, Fig. 4, *F'*). Solid and substantial, rounded posteriorly, notched anteriorly, and the edge divided into an upper and lower lip, between and in the centre of which the anterior pedal gland opens (*L.S.* and *P.G.*, Fig. 4). This gland takes the

¹ [*Morio*, Montfort, is an older name.—Ed.]

form of a straight tube about 8 mm. long. The whole of the foot, perhaps through contraction caused by the preserving fluid, is tuberculately reticulated and the margin crenulated. Kiener shows the foot with a broad untesselated margin, but I could trace no suggestion of this.

Operculum. Distinctly oval, and in texture and colour horny, semitransparent, subconcentrically striate, with the nucleus nearly marginal. It measures 32 by 14 mm.

Tentacles (Figs. 1, 2, 3, *L.T.*, *R.T.*) two in number, long and fairly thick, decreasing rapidly in size towards their free ends, but somewhat bluntly pointed. Corrugated and transversely striated through contraction.



Eyes (Figs. 1, 2, 3, *R.E.*, *L.E.*) two in number, placed on tubercles at the base and on the outside of the tentacles. They are pigmented with black, as are, to some extent, the tubercles.

The *rhynchostome* (Fig. 2, *Rh.*) is a plain, simple, rounded opening.

The *introvert* (Fig. 2, *Inv.*) is comparatively short, and conical in shape, with a bulbous swelling at the free end, flattened dorso-ventrally, transversely striate, thick-walled and muscular, especially towards the posterior, where it is attached by two more or less distinct bands of muscles (the introvert retractors, Fig. 1, *R.M.*) to the underside of the floor of the pallial chamber. It is pigmented with purple towards the free end, deepening in colour as the mouth is reached.

Alimentary Canal. The mouth appears as an apparently transverse slit at the free end of the proboscis or introvert.

On slitting open the proboscis (Fig. 2, *Pb.*) the buccal mass is revealed, and on making a longitudinal slit in this the mouth is seen to be provided with two hardened plates, an upper and a lower, of a brilliant orange colour, the margins being deep reddish purple. At the corners of the mouth are two small horseshoe-shaped areas tinged with purple, their use not being quite apparent to me, unless they act as gussets and allow the lips to open or form a disc or sucker, and so give the animal a firmer hold of its prey, and having drilled the shell, suck the contents to within reach of the radula.

Behind the hardened plates is the odontophore, bearing the radula, which is rather short, and distinctly visible on account of its bright purple colour.

The *buccal chamber* is elongated (Fig. 5, *A* and *D*, *Oe.*) and apparently extends the whole length of the introvert, and the hinder part is much sacculated internally. On leaving the buccal chamber the œsophagus is not folded on itself, but is constricted and dips downward, and here the nerve-collar is placed. The constriction continues for a short distance, when it suddenly enlarges, forming the crop (Figs. 1 and 5, *Oe'.*). This enlargement only affects the line of the upper portion of the tube, and is different in texture from the lower portion, its surface showing a cross hatching of fine muscular fibres. The crop continues, though slowly decreasing in size, till it passes underneath the division-wall at the far end of the pallial chamber, at which point it rather suddenly decreases and becomes the true œsophagus. The crop has a complicated internal structure, being provided from end to end with a number of transverse lamellæ pigmented with brown (Fig. 5, *B*, *C*, and *D*, *Oe'.*). They are cut through in the drawing and laid back. They spring from and are connected to a longitudinal fold shown to the left in the above figure. They may be secretory organs, as they have a spongy glandular appearance and give a distinctly alkaline reaction with red litmus, but I could get no reaction on testing for glycogen. This may have been destroyed by their long immersion in formaldehyde. Two raised folds run the length of the crop, and these, as far as I could make out, are not tubes. The one to the right is very distinct and much folded longitudinally, the one to the left being much less distinct. In life they may form a guide for the masticated food and also prevent its coming into actual contact with the lamellæ, though open to the action of their secretion, if any. On leaving the neighbourhood of the pallial chamber the walls of the œsophagus get much thinner, and it slowly enlarges till the stomach is reached. This organ is embedded in the liver and its walls are practically transparent, the openings of the hepatic ducts being distinctly visible.

The *stomach* is situated in the bight of the U described by the single turn of the alimentary canal, and is not easily separated from the small intestine, the size decreasing gradually. The intestine on leaving the stomach turns to the right, penetrating the kidney sac and traversing the nephridium. At its junction with the large intestine

or rectum (Fig. 1, *Re.*) there is an enlargement. The latter is thick-walled, muscular, and corrugated, supported throughout its whole length by folds of the inner membrane of the mantle, till the anus (Fig. 1, *An.*), which is free, is reached. The rectum lies to the right of the retracted penis, and the anus is some distance from the free edge of the mantle.

Salivary Glands (Figs. 1 and 5, *R.S.G.*, *L.S.G.*, *R.S.G'*, and *L.S.G'*). There are four of these, two on each duct. The primary glands (*R.S.G.* and *L.S.G.*) are much larger, semitransparent, membranaceous, and loose in texture. They are divided into lobes, of which I made out six in the right-hand gland and four in the left. These glands are situated at the ends of the ducts. The secondary glands (*R.S.G'* and *L.S.G'*) are considerably smaller, of very close texture, and irregular shape, and of an opaque, dead white appearance, that on the right-hand side being more or less embedded in the primary gland, while that on the left is situated some little distance along the duct, and is traversed by a nerve, *N'''*. The glands, as a whole, when *in situ*, lie behind one another, covering the crop. The duct of the posterior glands runs along the left-hand side, and that of the anterior along the right. The salivary ducts (*R.S.D.* and *L.S.D.*) open into the sacculate chamber of the hinder part of the buccal mass, just passing through the nerve-collar. They enlarge somewhat before entering, and apparently do not lead directly into the buccal chamber, but into the saccular folds, which are hollow.

Lang states, in his "Textbook of Comparative Anatomy," that the secretion of the salivary glands of *Cassidaria*, amongst other genera, contains an amount of free sulphuric acid from 2.18 to 4.25 per cent.; this can only be when the glands are fresh, for on testing I found the secretions of both primary and secondary glands to have a distinct alkaline action on red litmus. This fact, though of interest, is perhaps not of much value, on account of the artificially preserved state of the animal. A. H. Cooke mentions that the acidity of this secretion was first noticed by Troschel in *Dolium galea*, the animal being alive at the time. Fischer states that it is the posterior gland which secretes sulphuric acid, and Coupin, mentioning this, refers the statement to Fischer, who also remarks that Panceri found the acid in the salivary glands of *Murex*, *Cassis*, *Tritonium*, *Pleurobranchus*, etc.

The liver is a large granular-looking organ, occupying, with the testes, the whole of the visceral sac behind the kidney, the latter occupying the upper part. In colour it is brownish green, and the cells are distinct; it is divided into two lobes, each of which is provided with a duct opening into the upper side of the stomach (Fig. 6, *H.D'*, *H.D'*). The lobes of the liver are bound together with a very strong connective tissue, and in consequence is troublesome to dissect without destroying its texture and breaking the cells.

Pallial Complex. The free edge of the mantle is entire, simple, and not reflected, with a thin, sharp edge. The branchial chamber is extensive, and contains a highly developed bipectinate osphradium (Fig. 1, *Os.*) situated on the roof of the pallial chamber, quite to the left-hand side and running along the base of the ctenuidium. The folia

are deeply pigmented with green. With reference to this organ I feel I cannot add anything to the excellent account given by F. Bernard (5), and must admit I have been unable, from want of time and material, to give it very detailed attention as far as the histology is concerned. The large central nerve ganglion can be made out without difficulty on account of its being unpigmented.

The *ctenidium* (Fig. 1, *Ct.*) is of the usual monopectinate type, and is situated on the roof of the pallial chamber, to the left of and close to the osphradium. At its base runs the thin-walled vessel carrying the aerated blood to the heart. It is faintly pigmented with pink, and is attached to the mantle, from end to end, by more than half its under-surface. It finishes some little distance from the free edge of the mantle, and is so placed as to receive directly the inflowing stream of water from the syphon.

The *syphon* is short, and, as far as I could make out, has no appendages. It is formed by a fold in the mantle, which is much thicker on the left-hand side of the animal than on the right.

Hypobranchial Glands. These do not appear to be particularly well developed, though they cover a considerable area of the under-surface of the mantle in the neighbourhood of the *ctenidium*. They are formed by a number of folds of the inner membrane, very slightly pigmented with pink.

The pallial chamber was filled with a very tough mucous.

Nephridial Opening. This is placed at the back of the pallial chamber, in the wall separating the chamber from the nephridium.

Nephridium. Of large size, and rendered distinctly visible from the outside by a purplish tint when the animal is looked at after being taken out of the shell. It is in the form of a sac situated to the right hand of the pericardium, immediately behind the pallial chamber, from which it is separated by a thin and nearly transparent membrane, in which, as before mentioned, is situated the slit-like excretory orifice, surrounded by muscular fibres forming a sphincter. No part of the excretory tissue appears to be attached to this thin division-wall. The nephridium is traversed by the intestine, by which it is practically divided into two lobes. The internal structure of the organ is very complicated and has a more or less honeycombed appearance and a spongy texture, the divisions being formed by the ramifications which appear to be connected to two longitudinal axes, one on each side of and running parallel to the traversing intestine. The colour of the gland is brownish.

Reno-Pericardial Canal. Unfortunately the pericardium broke away owing to the weight of the visceral sac, and I could not trace the canal. Perrier states that it is very short, being only 2 mm. long and .5 mm. in diameter.

The *nephridial gland* is distinct both in colour and appearance from the nephridium, and occupies two sides of the sac, namely, those bordering the pericardium and the anterior border. Its canals ramify more or less under the general mass of the nephridium.

REPRODUCTIVE SYSTEM.

Penis (Fig. 8, *P.*). Very large and directed backwards when retracted, more or less oval in section, the free end curving downwards following the curve of the floor of the pallial cavity, blunt at the apex. At the right-hand side near the apex is a small pointed papilla (Fig. 8, *P.P.*).

Testis. Is a large whitish, somewhat granular-looking organ, which divides with the liver, as before mentioned, the visceral sac, and reaches quite to the apex.

The duct leading to the vas deferens is very short (Fig. 1, *S.D.*) where it has been cut through and the visceral sac turned back, joining the vas deferens at *S.D''*., Figs. 1 and 8.

Seminal Duct. Directly after entering, the duct enlarges very suddenly, forming a pear-shaped receptaculum (Fig. 8, *R.*), which contained a certain amount of a reddish-brown granular substance. The upper part of the walls of this receptaculum are rather thin, and it is attached on the underside to the floor of the pallial chamber.

On leaving the receptaculum the seminal duct or vas deferens (Fig. 8, *S.D.*) runs through a thick-walled tube which is formed by a thickening of the floor of the pallial chamber, semicircular in section; this becomes free as the base of the penis proper is reached.

The large penis is nearly solid (shown in section, Fig. 8), and in section the seminal duct shows as a vertical slit at the right-hand side (Fig. 8, *S.D''*.), and follows the contour of the organ right round the blunt extremity till it reaches the outlet at the papilla.

CIRCULATORY, NERVOUS, AND MUSCULAR SYSTEM.

Want of material has prevented my paying particular attention to these important parts of the anatomy of the animal.

The *heart* is of the usual monotocard type, and is provided with a very thin-walled auricle (Fig. 7, *Au.*) and a thick-walled and muscular ventricle enclosed in the pericardium. It is situated at the base of the kidney. The large thin-walled efferent vessel (Fig. 7, *Ef.V.*) carrying the aerated blood to the heart makes a U-shaped turn before entering the pericardium. The aortic trunk (Fig. 7, *Ao.*) swells on leaving the ventricle and then decreases in size. The aorta soon divides, the branches leading in opposite directions, one supplying the anterior and ventral parts of the body and the other the organs contained in the visceral sac.

Nervous System. I can say but little with regard to this. The nerve-collar, situated round the œsophagus close behind the buccal mass, is enveloped in a dense sheath of connective tissue, and the ganglia are not particularly distinct. The two cerebral ganglia above the œsophagus and the two pedal ganglia below it are to some extent distinct on account of their yellowish tint. The pleural ganglia are not so distinct and appear to be placed rather low, so that the cerebro-pleural connectives are longer than the pleuro-pedal. The right pleuro-visceral connective is a very distinct flat band, 2 mm. wide, which runs a little to the left-hand side of the crop after crossing over from the right pleural ganglion.

The *muscular system* is well developed, but I was unable to follow this out in detail. The columellar muscle is very strong, and has a glistening appearance where it clasps the columella. The introvert muscles have already been mentioned, and I regret not being able to give a definite account of the muscles actuating the radula.

The *radula* has a formula 2:1:1:1:2, and is tinted a fine red purple colour. The forms of the teeth are shown in Fig. 9, much enlarged. The central tooth is multicuspid, the central cusp being much the largest, and there appear to be about seven smaller cusps on each side. The laterals are multicuspid, the first being much the largest, and is directed inwards and downwards. The uncini are long, curved, and simple.

The forms of the radula teeth are not unlike those of *Cassia sulcosa*, Born, as given by Cooke, but in that species neither the middle cusp of the central tooth nor the first cusp of the laterals is so well developed. In *Cassia saburon*, Adanson, according to Woodward, the innermost of the uncini are cusped.

Not being familiar with the anatomy of forms allied to *Cassidaria rugosa*, I am unable to go into details of comparison, but hope at some future date to have the opportunity.

In conclusion, I must thank Mr. E. A. Smith, Mr. E. R. Sykes, and Mr. R. H. Burne for their kind assistance, and for the trouble they have taken in aiding me with suggestions and references.

BOOKS CONSULTED.

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- (5) F. Bernard: "Recherches sur les organes palléaux des gastéropodes prosobranches," 1890.
- (6) H. Coupin: "Les Mollusques," 1892.
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- (8) A. Lang: "Textbook of Comparative Anatomy" (transl.), 1896.

EXPLANATION OF PLATE XV.

FIG. 1.—Animal with the mantle cut away along the right side and folded back. The part carrying the rectum had to be divided from the rest to enable the folding back to be done without destroying various tissues. The penis has been pushed a little to one side, and the seminal duct cut through and turned away. The floor of the branchial cavity is cut away, in part exposing the salivary glands and a portion of the crop.

FIGS. 2-4.—In the text.

FIG. 5.—*A*, plan showing buccal mass, salivary glands, and crop; the introvert laid open. *B*, the posterior part of the crop laid open. *C*, transverse section of crop. *D*, anterior part of crop and posterior part of the buccal mass laid open, showing saccululation and entrance of salivary ducts.

